Strata Preservation On The Inner Eel River Shelf, Northern California

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LONG-TERM GOALS

The long-term objective within the STRATAFORM research program is to investigate the processes that lead to the genesis, modification, and burial of fine-scale stratification in continental shelf sediments. The approach is to: a) sample the continental shelf immediately after events and at closely spaced intervals thereafter, to monitor the shorter term (months to years) changes that modify the distribution and character of event layers and b) examine the preserved stratigraphy in the upper few meters of the seabed to examine the characteristics and fate of event layers over the longer term (10 - 1,000 years).

OBJECTIVES

The objectives of this project include:

1) to identify the results of major flood and storm events on the sedimentology and stratigraphy on the inner continental shelf and
2) to investigate the along- and across-shelf variability of event layer character and preservation as applied over decades to thousand-year time scales.

APPROACH

From 1995 through 1998, box cores were collected on the Eel shelf in rapid response to major environmental events. Rapid-response sampling allowed us to obtain seabed samples immediately following a number of these events. The depositional character of the sediments deposited on the middle and outer shelf after the 1995 and 1997 events as well as modifications that have occurred to the initial deposit have been described (Wheatcroft et al. 1996, 1997; Wheatcroft and Borgeld, 2000). The inner shelf had remained an area of uncertainty regarding its importance as an area of fine sediment storage and its potential for storm and flood layer preservation. To investigate the inner shelf, slow cores and vibracores were collected on sample transects that had been initially established during the rapid-response sampling. Examination of these cores indicates that flood deposits have been preserved at depth on the inner shelf. The inner shelf cores have been examined and coupled with side-scan sonographs and CHIRP seismic records that were collected on the inner shelf by N. Driscoll (personal communication) and with Multi-beam Swath surveys collected in the same general area by R. Flood and V. Ferrini (personal communication).

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14. ABSTRACT
The long-term objective within the STRATAFORM research program is to investigate the processes that lead to the genesis, modification, and burial of fine-scale stratification in continental shelf sediments. The approach is to: a) sample the continental shelf immediately after events and at closely spaced intervals thereafter, to monitor the shorter term (months to years) changes that modify the distribution and character of event layers and b) examine the preserved stratigraphy in the upper few meters of the seabed to examine the characteristics and fate of event layers over the longer term (10 - 1,000 years).

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WORK COMPLETED

During FY 2001, cores that were collected on prior cruises were coupled with side-scan sonagraphs and multibeam data. The data were used to examine the morphology of the seabed and evaluate the conditions under which strata were preserved on the inner shelf

RESULTS

For the past few years, STRATAFORM researchers investigating modern processes on the Eel River margin have provided new perspectives on the processes and the sequence of events that result in event-layer creation and preservation in a shelf environment. Recent observations and modeling suggest that deposits associated with the deposition of fine-grained sediments on the mid- and outer-shelf (water 60 meters and deeper) may be short lived without rapid burial (Wheatcroft and Borgeld, 2000; Wiberg, 2000, Zhang et al., 1999). The intense wave climate (waves with heights greater than 8 m are an annual occurrence) results in bottom sediment reworking on a regular basis. In addition, on the mid- and outer-shelf the impact of bioturbation in the upper 10-12 cm is so intense that preservation of an event bed requires rapid burial below this zone. This lesson was learned from tracking the 1995 and 1997 flood-event horizons on the mid-shelf. Three floods in rapid succession provided a mechanism for preservation of the 1995 deposit. In January 1995, an Eel River flood event occurred with an approximate recurrence interval of 30 years (Wheatcoft, 1997; Syvitski & Morehead, 1999). This event was followed by a smaller, but significant flood event in March of 1995. The 1995 events were followed by an even larger flood event in January of 1997, recurrence interval approximately 80 years (Syvitski & Morehead, 1999). The burial of the 1995 deposit by the 1997 minimized the effects of bioturbation and subsequent wave events, which led to its preservation. The 1997 deposit, although a larger flood event, remained near the sediment surface and any evidence in the form of physical strata has been all but obliterated. Although evidence of the event does remain in the form of finer-grained average sediment sizes (Drake et al., 2000).

Vibracores and hydraulically-damped piston cores collected on the inner Eel River shelf (shallower than 55 meters) reveal the presence of several muddy horizons buried at depth in the inner shelf sands. The preserved sediments are fine-grained silts and clays similar to the flood-related deposits encountered elsewhere on the shelf in 1995 and 1997. On the inner shelf , the enhanced wave reduced the likelihood of event layer preservation. For example, bottom wave velocities calculated for 30 m depth indicates that wave velocities exceed threshhold conditions an average of 270 days per year; the bed is almost always in motion during the winter (Wiberg, 2000). As on the mid- to outer shelf, rapid burial is required to preserve any of these deposits. The restricted area of preservation suggests that the burial that occurred was localized. These preserved beds were encountered on a section of the shelf, about 10-12 km north of the river mouth.

Investigators working on other shelves have noted inner shelf slope failure and have recognized the possible importance of such events in the creation and preservation of the sedimentary record. For example, Field et al. (1981) documented an inner shelf slope failure on the Klamath River shelf, just north of the Eel River shelf that occurred in response to a magnitude ~7 earthquake on November 8, 1980. The failure resulted in a terrace about 700 m wide with a leading edge scarp 1.0-1.5 m high and was not thought to represent a fault rupture. The seaward edge of the feature extended to depths ranging from 61-67 m.

Side-scan sonar profiles and hydraulically-damped piston cores collected from the inner Eel shelf indicate that slope failure and slumping are important mechanisms on the Eel River shelf, as well. One such failure was recognized during a cruise in the summer of 1998 (W9807). Cores were collected from within and outside of theslump zone. The cores help identify a sandy surface layer, 10-15 cm thick, overlying higher porosity clayey silts that match the character of surface flood layers that were cored immediately after the 1995 and 1997 floods. Cores collected from outside the slump zone displayed no mud layers. The interpretation is that these layers were preserved by being rapidly buried by the submarine slumping.

Evidence for slumping at other areas of the inner shelf is indicated in the side-scan sonagraphs. The slumps were prevalent in the same area of the shelf where vibracoring revealed the fine-grained layers preserved at depth in the otherwise fine sand and coarse silt inner shelf. The correspondence suggests a causal relationship. In particular, that slope failure and slumping have occurred on the inner Eel Shelf and represent a primary mechanism for the preservation of flood-event strata on the inner shelf.

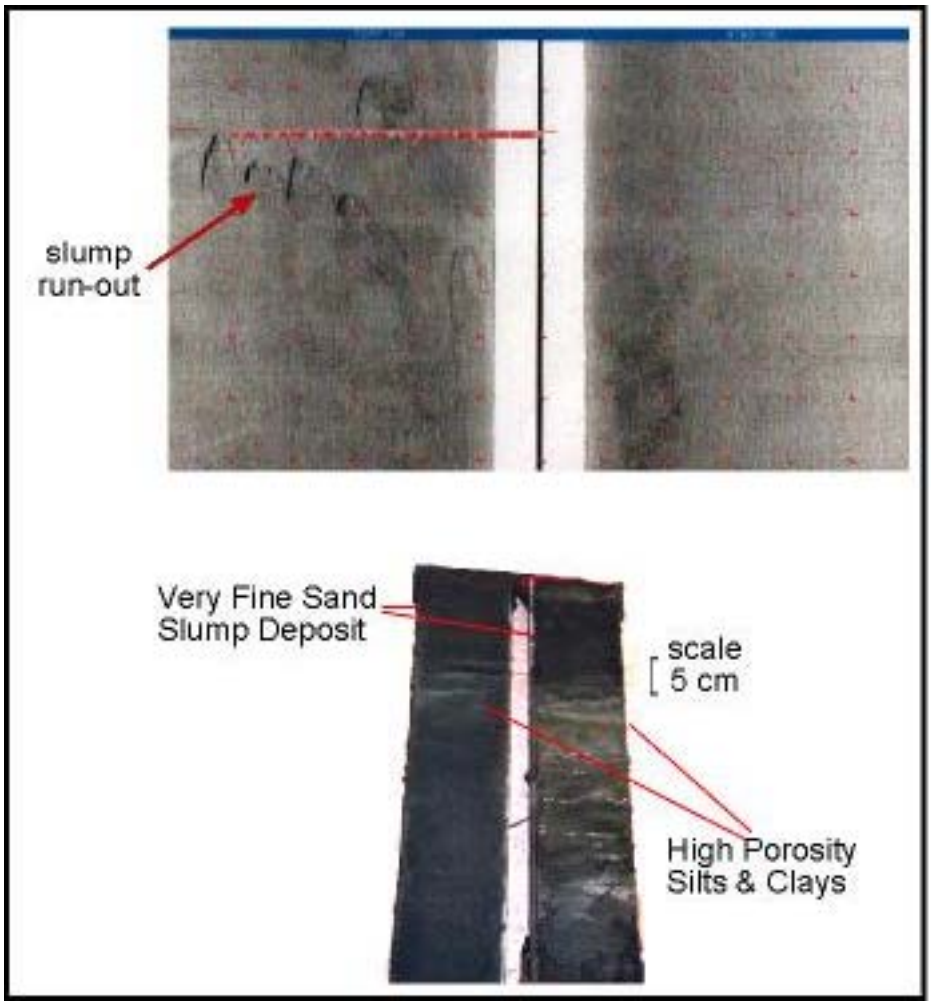

Figure 1. Sonograph of inner shelf slump run-out with core photos from run-out zone, showing muddy strata preserved 10 to 12 cm below the seafloor.

IMPACT/APPLICATIONS

A better understanding of the conditions under which shelf sediments are preserved, in an active setting such as the Eel Margin, will undoubtedly lead to a better understanding of shelf sedimentation. The inner shelf is of particular interest as these rocks are commonly used to aid in the interpretation of preserved shelf sequences. The role of tectonics in such sedimentary processes has application to a large proportion of such settings around the globe.

TRANSITIONS

These results are being used by a number of other investigators within the STRATAFORM research program. For example, the understanding and interpretation of high-resolution seismic data has been aided by the analysis of the longer sediment cores. Investigators interpreting recently collected Multibeam Swath data (Ferrini et al. 2000) have utilized some of these results in their interpretation. In addition, the recognition of the offshore expression of slope failure will aid in the interpretation of the tectonic effects along the northern California coastline and will aid in the evaluation of seismic hazards along the coast.

RELATED PROJECTS

Including some of the projects identified above, related projects include: D. Drake , flood and storm sediment modification over annual time scales; N. Driscoll, high-resolution CHIRP seismic structure of the Eel Margin; R. Flood, Multibeam Swath mapping of the inner Eel Shelf; C. Nittrouer, sedimentary character of the Eel Shelf; R. Wheatcroft, event-scale sedimentary processes on the Eel Shelf.

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